ISSN: 2349-6495

Automatic Load Frequency Control of Multi Area Power System using Fuzzy Logic

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Abstract*—*This paper provides of using of computing technology for controller application in power system. PI controller is mostly used in industrial application to control the different parameters in power system. Conventional PI controllers are not efficient for multi area power system because of high peak over shoot and settling time. The main focus of of this work is on the controller to obtained good output frequency response .The output response of proposed Fuzzy controller shows better performance and found reasonably good compare to conventional controllers.

Keywords*—*Conventional controller, Proposed Fuzzy controller, Tie-line, frequency, Load, Load frequency control(LFC).

I. INTRODUCTION

Power system frequency is one of the most important factor of power quality, whose stability is related to safety and efficiency of user's power equipment as well as generation and supply electric equipment. The successful operation of interconnected power systems requires the matching of total active power with total load demand. Automatic generation control (AGC), whose main goals are to maintain zero steady state errors for frequency deviation and to ensure tie-line exchange power on schedule in a multi-area deregulated power system, is a very significant issue in power system operation and control for supplying sufficient and reliable electric power with good quality. Due to the influence of multi-area interconnect and power market, power system becomes more and more large scale and complex. Thus, conventional control strategy, fixed PI control, couldn't meet the demand of power system in new environment because of unsatisfactory dynamic response such as long adjust time, large overshoot, poor handling of system nonlinearities. Many investigations about new control policies on the basis of PI control have been reported pertaining to AGC system in the past.[1] A proportional-integral (PI) controller is used to regulate the frequency of each area, the input signal of the PI controllers is ACE, whose parameters tuning are selected depending on the control area characteristics. PI controllers meet most of the 90% of industrial needs. The popularity of PI controllers is due to their functional simplicity and reliability because they provide robust and reliable performance for most systems. Many control schemes such as the conventional proportional-integral (PI) controller, the proportional-integral-derivation (PI) controller and optimal control have been proposed to achieve improved performance.[2] With the aid of FL, different alternative, intelligent PI controllers have been recently proposed. Fuzzy logic controller (FLC) is credited with being a suitable method for designing robust controllers that are able to provide a desirable efficiency while facing uncertain parameters. The most important problem related to the FLCs is that they cannot completely be used for the linguistic and numerical uncertainties in variable environmental conditions as they apply accurate fuzzy sets. Fuzzy sets apply the uncertainties related to the FLC inputs and outputs by employing precise and crisp membership functions. Since fuzzy membership functions are completely accurate, all uncertainties are eliminated when the fuzzy membership functions are selected. The linguistic and numerical uncertainties in variable environmental conditions make problems in the exact consequent of membership functions over the design procedure. Recently, FL has been extensively utilized for identification, modeling and control of nonlinear dynamic systems. Several combinations of control approaches are proposed to improve the performance of fuzzy PI or PID controllers.[3]

II. WHY FREQUENCY CONTROL IS NECESSARY

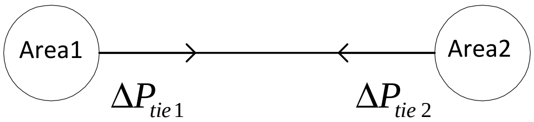
2.1 The three phase A .C. Motors running speed are directly proportional to the frequency. So the variation of system frequency will directly affect the motor performance.

2.2 For synchronous operation of various unit in the power system network, it is necessary to maintain frequency constant.

2.3 The blades of the steam turbine and the water turbines are designed to operate at a particular speed and the frequency variations will cause change in the speed. This will lead to excessive vibration and cause damage to the turbine blades.

III. TWO AREA POWER SYSTEMS

Two areas 1 & 2 are inter connected through a tie line. Power which is flowing out of the area is taken as +ve power and the power flowing inside the area is taken as –ve power. Here, ΔP_{tie} is showing the change in tie line power in MW. Then losses in tie line are vary - vary small so we can neglect it. For the two area system the tie line power $\Delta P_{tie\text{-}1}$ must be equal to the negative of $\Delta P_{tie\text{-}2}$, if both are in MW. (ΔP_{tie} represents the tie line power in p.u. MW of the area capacity P_r). $P_{r1}\ \Delta P_{tie\text{-}1} = -\Delta P_{tie\text{-}2}\ P_{r2}$, Where, P_{r1} and P_{r2} are the rated power of the area and when they are multiplied by the ΔP_{tie} we get the actual power.



$$\Delta P_{tie\text{-}2} = -\frac{P_{r1}}{P_{r2}} \Delta P_{tie\text{-}1}$$

$$\Delta P_{tie\text{-}2} = a_{12} \Delta P_{tie\text{-}1}$$

$$Where,\ a_{12} = -\frac{P_{r1}}{P_{r2}}$$

$$\Delta P_{tie\text{-}1} = 2\pi T_{12} \left[\int \Delta F_1 dt - \int \Delta F_2 dt \right]$$

$$\Delta P_{tie\text{-}1}(s) = \frac{2\pi T_{12}}{s} \left[\Delta F_1(s) - \Delta F_2(s) \right]$$

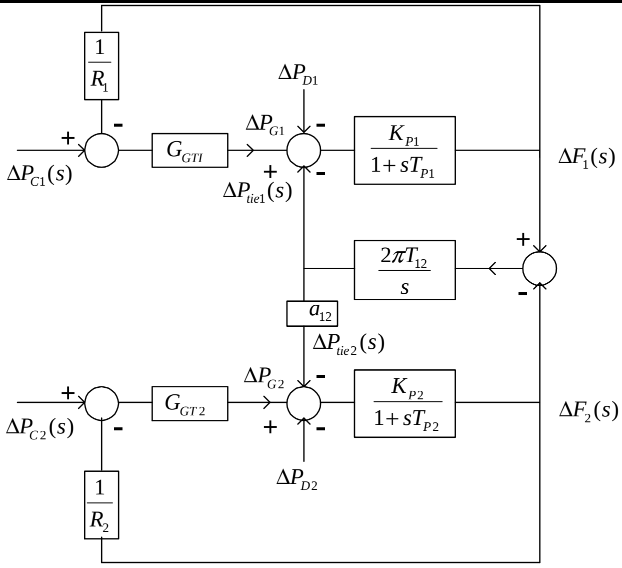


Fig. 1: Block diagram of two area power system.

ΔF_1, frequency deviation of area1 [Hz].
ΔF_2, Frequency deviation of area 2 [Hz pu].
T_{p1} and T_{p2}, Time constant of gen1 and gen2 respectively.
R_1 and R_2, Speed Regulation of area1 and area2 respectively.
K_{p1} and K_{p2}, Gain constant of gen1 and gen2 respectively.
ΔP_{D1} and ΔP_{D2}, Change in load demand of area1 and area2 respectively.
ΔP_{C1} and ΔP_{C2}, Change in speed changer position of area1 and area2 respectively.
T_{12}, Gain of power system.

IV. CONTROLLERS

There are different types of controllers proportional integral, derivative, combinational of these controllers and fuzzy controller.

4.1 PI controller.

The integral control consists of frequency sensor and an integrator. The frequency sensor measures the frequency error Δf and this Area Control Error(ACE) is fed into the integrator. The integrator produces a real power command signal ΔP_c and is given by $\Delta P_c = -K_I \int \Delta f\ dt$, where K_I = Integral gain constant

$$= -K_I \int ACE\ dt$$

4.2 Fuzzy controller

The Fuzzy logic control consists of three main stages, namely ethe fuzzification interface, the inference rules engine and the ddefuzzification interface. For Load Frequency Control the pprocess operator is assumed to respond to variables error (*e*) aand change of error (*ce*).[4]

ISSN: 2349-6495

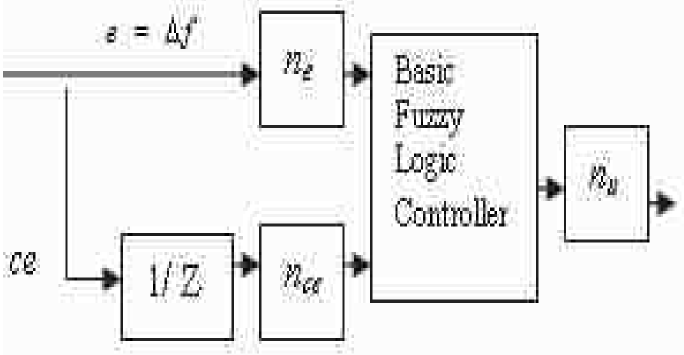


Fig.2: Block diagram of a fuzzy logic controller.

The variable error is equal to the real power system frequency deviation (Δf). The frequency deviation is the difference between the nominal or scheduled power system frequency (f_n) and the real power system frequency (f).Taking the scaling gains into account, the global function of the FLC output signal can be written as.Δ*Pc* = *F*[*nc* e(k), nce ce(k)] Where, ne and nce are the error and the change of error scaling gains, respectively, and F is a fuzzy nonlinear function. FLC is dependent to its inputs scaling gains .The block diagram of FLC is shown in Figure-2. Output control gain is *nu* and z is the maximum membership degree .

V. SIMULATION AND RESULT

5.1 Simulation of two area with pi controllers.

When step load change takes place in both area then an integral controller is added to each area of the uncontrolled plant in forward path. The steady state error in the frequency becomes zero. The task of load frequency controller is to generate a control signal u that maintains system frequency and tie-line interchange power at predetermined values.

$$\mathrm{ui} = -\mathrm{Ki}\int_0^{\tau}(\mathrm{ACEi})dt = -\mathrm{Ki}\int_0^{\tau}(\Delta \mathrm{Ptie,i} + \mathrm{bi}\Delta \mathrm{fi})dt$$

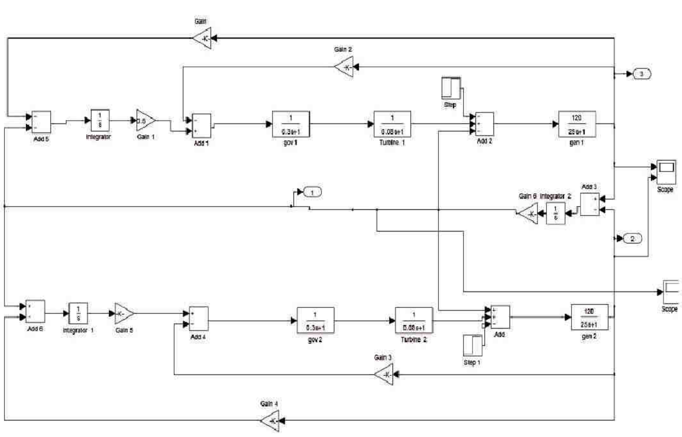


Fig.3: Simulink of two area with pi controller.

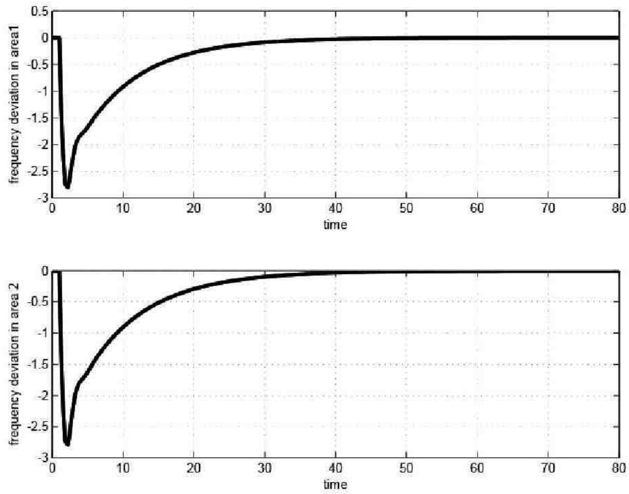


Fig.4: Frequency deviation of area1 and area2 with step load.

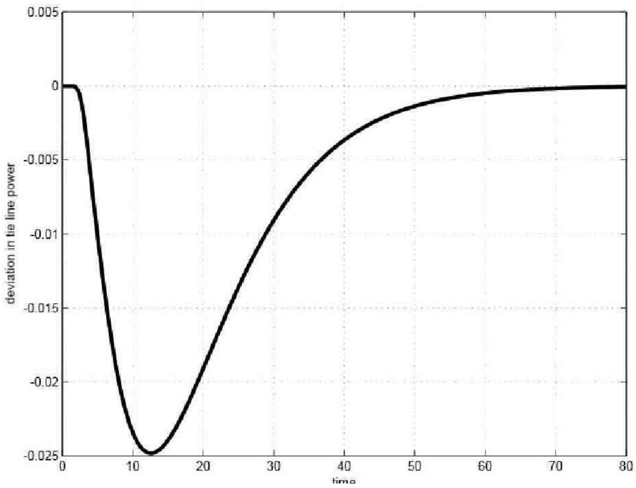


Fig.4: Deviation tie line power with PI controller.

5.2 Simulation of two area with proposed Fuzzy controller.

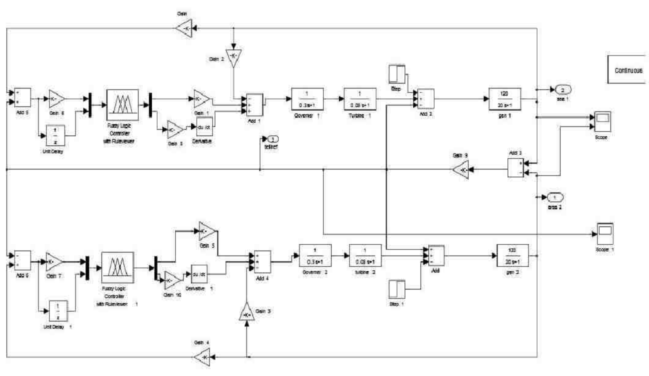


Fig.5:Simulink two area with proposed fuzzy controller.

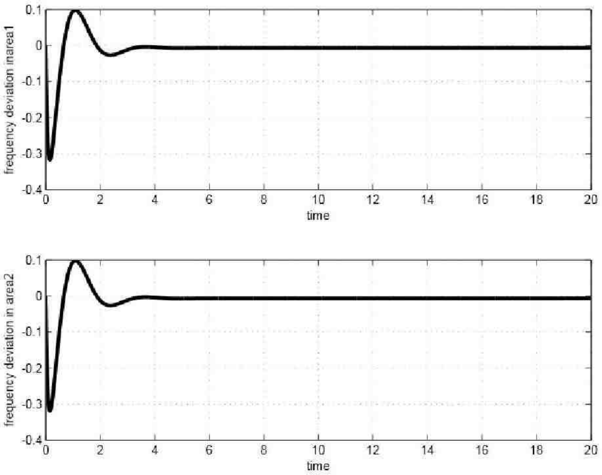


Fig.6:.Frequency deviation in area1 and area2.

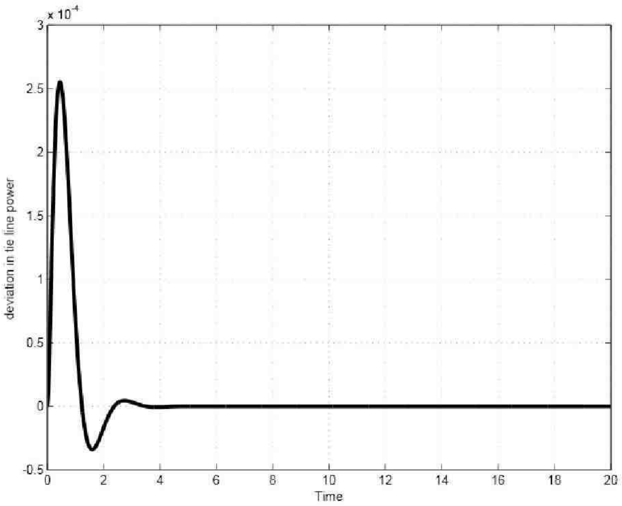


Fig.7: Deviation in tie line power with proposed fuzzy controller.

Table 1. Comparison of dynamic performance of controllers

Controllers	Output parameter	Peak over shoot	Settling time (sec)
PI controllers	ΔF_1	2.59	40
	ΔF_2	2.57	39
	$\Delta P_{tieline1}$	0.025	70
Proposed fuzzy controller	ΔF_1	0.3	4
	ΔF_1	0.3	3.9
	$\Delta P_{tieline2}$	$2.5x10^{-4}$	3.5

VI. CONCLUSION

In this paper, the proposed fuzzy controller is used to solve the load frequency control problem of two area power system. Simulation results (Table-1) show that the proposed fuzzy controller in damping of frequency deviation and also tieline power deviation of power system has better performance than the PI controller.

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